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Photographic Census Surveys of the St. Lawrence Beluga Population, 1988 and 1990

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ABSTRACT

Photographic aerial surveys were flown to estimate the size of the population of belugas inhabiting the estuary of the St Lawrence River, Canada, on 31 August 1988 and on 12 Sept 1990. The surveys were systematic strip transect surveys, with sample coverage over the main area of beluga habitat of 37.5% to 50%, and 12.5% over an extension area. The cameras used were 9"x9" aerial mapping cameras. The population estimate obtained in 1988 (corrected for sun glare on the film, but not for submerged animals) was 427 belugas, with a standard error of 60. The 1990 result was 527 (std err. 268.) Counts of juveniles were higher in 1990 than in 1988; 23 closely associated cow-calf pairs were identified, compared with 3 in 1988.

RÉSUMÉ

Des recensements aériens de la population de bélugas du fleuve St-Laurent eurent lieu le 31 août 1988 et le 12 septembre 1990. Les recensements prirent la forme de relevés par échantillonnage, utilisant une grille de transects systématique. Le taux d'échantillonage fut de 37.5 p. 100 ou de 50 p. 100 dans l'aire la plus fréquentée, et de 12.5 p. 100 dans une aire additionelle. Les caméras utilisées avaient une largeur de cliché de 9 po. x 9 po. L'estimé de 1988 fut de 427 béluga (corrigé pour les images possiblement cachées par la réflexion du soleil, mais non corrigé pour les cétacés submergés) avec une erreur standard de 60. Les chiffres correspondants pour le recensement de 1990 furent de 527 (erreur standard 268). Le dénombrement des veaux étroitement liés aux femelles a révélé une forte difference entre les deux années étudiées: 23 paires en 1990 par rapport à 3 en 1988.

PREFACE

This report describes work carried out under the Interdepartmental Plan for the Survival of the beluga of the St Lawrence.

INTRODUCTION

The population of belugas (*Delphinapterus leucas*) inhabiting the St Lawrence estuary is considered to be endangered. In the earlier history of the St Lawrence, the belugas were harvested as a resource, at some periods in large numbers (Reeves and Mitchell 1984; 1987; Breton 1990.) In this century, belugas were not always favourably regarded, being suspected of adverse effects on stocks of commercially valuable fishes, and were for a time subject to a bounty hunt (Reeves and Mitchell 1987). Declining numbers destroyed the commerce in beluga products after the second World War, and continuing low population counts led to the legslation of an increased level of protection. The belugas of the St Lawrence River were fully protected by the Canadian government in 1979, by amendment to the Beluga Protection Regulations of the Fisheries Act.

The Committee on the Status of Endangered Wildlife in Canada approved and asssigned an 'endangered' status for the beluga of the St Lawrence on 6 April 1983. By then, the condition of the environment in general, and the prevalence in the environment of persistent artificial organochlorines - pesticides and others - became a subject of attention. The propensity of long-lived marine mammals to accumulate lipophilic compounds led to high levels of these pollutants in the belugas of the St Lawrence, and observations of the population appeared to support the view that it was still declining in size (Béland et al. 1987).

The Interdepartmental Action Plan for the Survival of the Beluga of the St Lawrence includes a research component designed to augment knowledge of the population in such ways as may be appropriate efficiently to direct management and protective measures. The research undertaken has included aerial surveys to study the size, distribution and movements of the population. This report presents the results of two census surveys of the population, carried out by photographic aerial survey, one at the end of August 1988 and the other in mid-September 1990.

METHODS

STUDY AREA, SURVEY DESIGN, AND FIELD METHODS

The survey area covered the middle estuary of the St Lawrence, and was sampled by transects across the St Lawrence estuary (Figs. 1 and 2) The transect headings were 310° and 130° true in 1988 and 330° and 150° true in 1990.

A stratified systematic strip transect sampling design was used for the surveys. In both years, the transects were spaced 2 nautical miles (n. mi.) (3.704 km) apart as far downstream as Les Escoumins. In a downstream extension area, transects were spaced 6 n. mi. (11.1 km) apart. There was no photographic coverage of the Saguenay Fjord. However, information on the numbers of belugas seen in the fjord on several visual overflights in September and October 1990 was incorporated into the data derived from the systematic surveys.

The surveys were flown using two aircraft simultaneously, in order to cover the survey area as quickly as possible and within the same day. The transects in the high-cover area were flown from the centre outwards, i.e. in opposite directions, to neutralise possible effects of coordinated movements of belugas upstream or downstream.

The observation platforms were light low-wing twin-engined aircraft: Piper 'Aztec' and Cessna 414. The cameras were 9" x 9" (228.6 x 228.6 mm) format metric mapping cameras (Wild-Leitz RC10 and Zeiss A15/23), fitted with 6" lenses. The cameras were loaded with colour aerial survey film in 200-foot rolls. In 1988 the film used was Kodak 2445 colour negative aerial survey film, and the interpretation was carried out directly from the negatives. Some difficulty was experienced in doing so, and in 1990 we switched to Kodak 2448 colour positive aerial survey roll film.

In 1988 the target altitude was 3000 feet (914.4 m), giving a coverage of 37.5 % in the high-coverage stratum, a nominal scale of 1:6000, and a target image size of 0.667 mm for adult belugas and 0.222 for neonates. This altitude was achieved for all the flying. In 1990, in order to get a wider strip on the transects, the target altitude was raised to 4000 feet (1219.2 m), for a coverage of 50 %, a nominal scale of 1:8000 and target image sizes of 0.5 mm and 0.167 mm. In the event, cloud cover forced part of the 1990 survey to be flown at 3000 feet, but the affected area was the downstream part of the survey where few belugas were expected to be found, and the flying in the upstream area where the principal concentrations are found was achieved at 4000 feet. The cameras were set at their minimum overlap for all the transects.

FILM INTERPRETATION AND DATA ANALYSIS

The film was counted on a light table using a dissecting microscope or a magnifier. Low magnifications were used, as the film grain was the limiting factor in identifying whale images. The film was counted twice, by a technician and by a specialist aerial survey film interpreter, and checked by an experienced survey observer.

A correction was made for sun glare, a diffuse solar reflection that prevents whales being seen in part of some frames. Glare areas were searched for whales. While some whales were found within the edges of glare areas, they were few. On one or two transects, whales close to a frame edge that should have been repeated in the glare area of the next frame could not be found there, confirming that glare does impede accurate counting. A glare correction factor was calculated by measuring frame overlap, and measuring the glare area not covered by the (non-glared) overlap of the next frame to the nearest one percent, using a ruled square grid. The distribution of belugas is known to be patchy, and the glare varied within each survey depending on the time of day (sun height), wind, and cloud cover. Therefore, local glare correction factors were estimated and applied in those regions where belugas were seen on transects; we did not estimate or use a mean glare correction over the entire survey. It was sometimes difficult to determine the overlap, owing to the lack of features on water, and in such cases, a nearby frame was sought which showed a convergence line or front, boat, buoy, bird, coastline or similar feature.

For data analysis, the counts were summed over transects, omitting repetitions of images on consecutive frames. Groups of adjacent transects were defined, each group homogeneous for transect spacing and flying height. For the i^{th} group an expansion factor k_i was calculated as

$$\begin{aligned} k_i &= S_i / W_i \\ &= S_i / (H_i \times B/L) \end{aligned} \qquad [1]$$

where: S_i = transect spacing for the i^{th} group;
W_i = transect width for the i^{th} group;
H_i = flying height for the i^{th} group;
B = photo frame breadth (228.6 mm for the metric mapping cameras used); and
L = lens focal length (153.1 mm for these lenses).

The estimate of numbers for the area sampled by this group was then given by

$$\hat{N}_i = k_i \left[\frac{x_{i1}}{2} + \sum_{j=2}^{J_i-1} x_{ij} + \frac{x_{iJ_i}}{2} \right] \qquad [2]$$

where: J_i = the number of transects in the i^{th} group;
x_{ij} = the number of whales counted on the j^{th} transect in the i^{th} group.

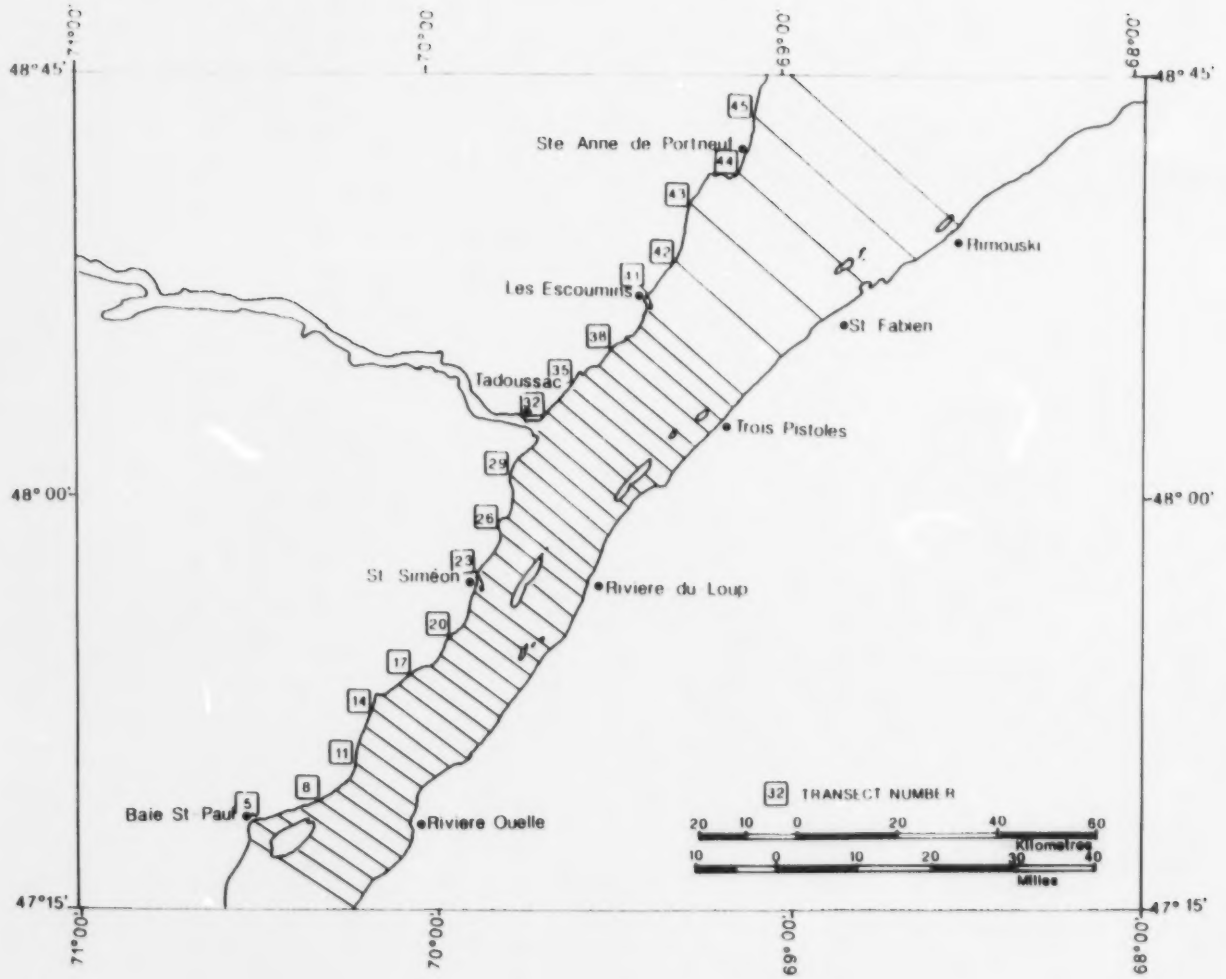

Figure 1. Transects for photographic aerial survey for belugas of the St Lawrence estuary, 31 August 1988.

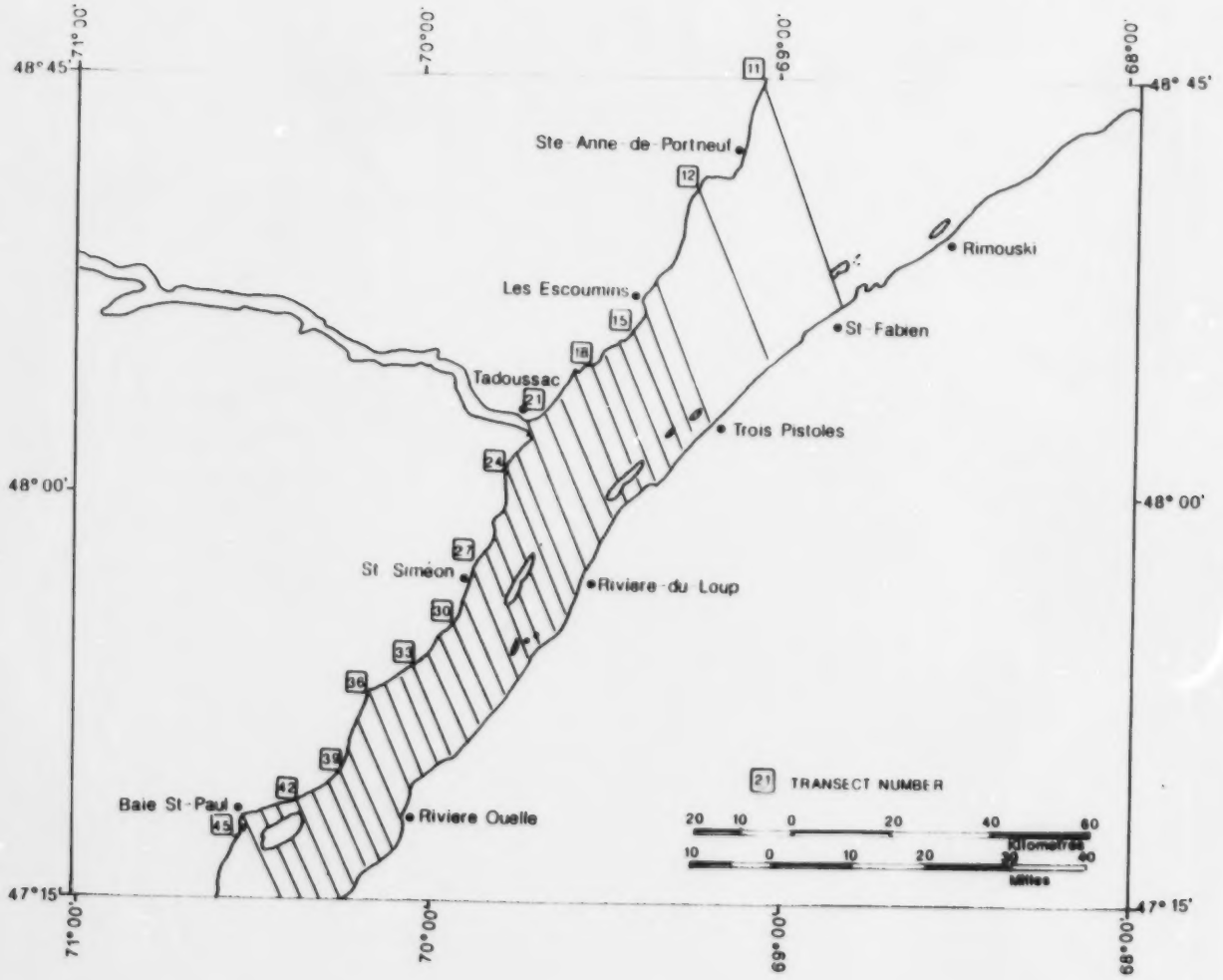

Figure 2. Transects for photographic aerial survey for belugas of the St Lawrence estuary, 12 September 1990.

This expression assumed that group boundaries lay on transect centres; i.e. that a group boundary was due to change of transect spacing. In such cases the boundary transect (e.g. transect 41 in 1988) was the end member of both the adjacent groups. Appropriate changes were made to the formula where group boundaries lay between transects (owing to change of flying height). For estimates using a glare correction factor, the corrected transect counts were used in this expression.

The serial difference methods of Kingsley and Smith (1981) for calculating error variance for density estimates (V_i) from systematic surveys were modified for this case in which the valid study area (i.e. the habitat area actually used by the population) was not precisely known and the statistic of interest was the population total rather than the spatial density of organisms. The expression used, (eq'n 8.44 of Cochran 1977), was

$$\hat{V}_i = \frac{k_i(k_i-1)}{2}\sum_{j=1}^{J_i-1}(x_j-x_{j+1})^2; \qquad [3]$$

including corrections for sampling from a finite population.

The combined estimate for the total population and its error variance were obtained by totalling the individual estimates for the transect groups:

$$\hat{N} = \sum_{i=1}^{I}\hat{N}_i$$
$$\hat{V} = \sum_{i=1}^{I}\hat{V}_i \qquad [4]$$

where I is the number of groups of transects.

A correction for submerged animals is appropriate for photographic aerial surveys of marine mammals, but it is difficult to estimate the value of such a correction. Uncorrected estimates (i.e. of visible whales) were calculated and are presented here, and such information as is available on diving correction factors was reviewed and a correction factor applied to estimate total population.

There are two methods of classifying the ages of young belugas: by size and by colour, as the dark grey calves lighten gradually to the white adult coloration. We were unable to differentiate colour gradations on the aerial survey film, and were also unable to make precise measurements of length on the small scale imagery. However, we were able to make approximate length measurements, and could identify whales that were distinctly shorter than the average adult length. Small whales were assigned to three classes. *Calves at heel* were defined as those that were physically very close to an adult and clearly less than half its length, with good image quality; *independent juveniles* were those well separated from the nearest other whale, but clearly and visibly shorter than adult images; *questionable juveniles*

were independent animals that looked shorter than adults but for which poor image quality due to distance below the surface, the attitude of the whale, or some other factor prevented us from being confident that this was so.

RESULTS AND DISCUSSION

POPULATION COUNTS

The weather in 1988 was calm, and in 1990 was ideal, with very calm conditions over most of the survey area. There were few extensive areas of breaking waves, which can interfere with film interpretation, or of widespread glare. In 1988 there was patchy cloud. In 1990 the sky was clear over the upstream part of the survey area, with thin layer cloud over the downstream area. Glare corrections varied, being generally zero or very small under cloud and for transects flown at the start of the survey when the sun was still low in the sky, and greater for survey transects flown in the middle of the day. The weighted mean glare correction was 2% in 1988 and 2.5% in 1990.

Table 1. Counts of beluga whales on photographic survey transects over the St Lawrence estuary, 31 August 1988.

Transect No	Count	Glare factor (%)	Corrected count	Transect No	Count	Glare factor (%)	Corrected count
Group 1: transects 1--41; S = 2 n. mi.; H = 3000 ft; k = 8/3							
17	21	1	21.21	33	6	9	6.59
18	9	0	9	34	13	0	13
19	3	0	3	35	15	2	15.31
20	1	0	1	36	4	9	4.40
				37	1	0	1
28	10	4	10.42	38	16	0	16
29	11	5	11.58	39	13	0	13
30	9	3	9.27	40	12	0	12
31	0	0	0	41	5	0	5
32	3	12	3.41				
Group 2: transects 41--52; S = 6 n. mi.; H = 3000 ft; k = 8							
41	5	0	5				

In 1988, all the transects were flown at 3000 feet, and all the belugas counted were in the high-coverage survey area where the transect spacing was 2 n. mi., including 5 that were counted on the boundary transect where the spacing changed between the 2-mile and the 6-mile spacing (Table 1, Fig. 3). None were counted in the extension area where the transects were spaced 6 n. mi. apart. The small number on the boundary transect made a small contribution both to the overall population estimate and to the overall standard error, and the

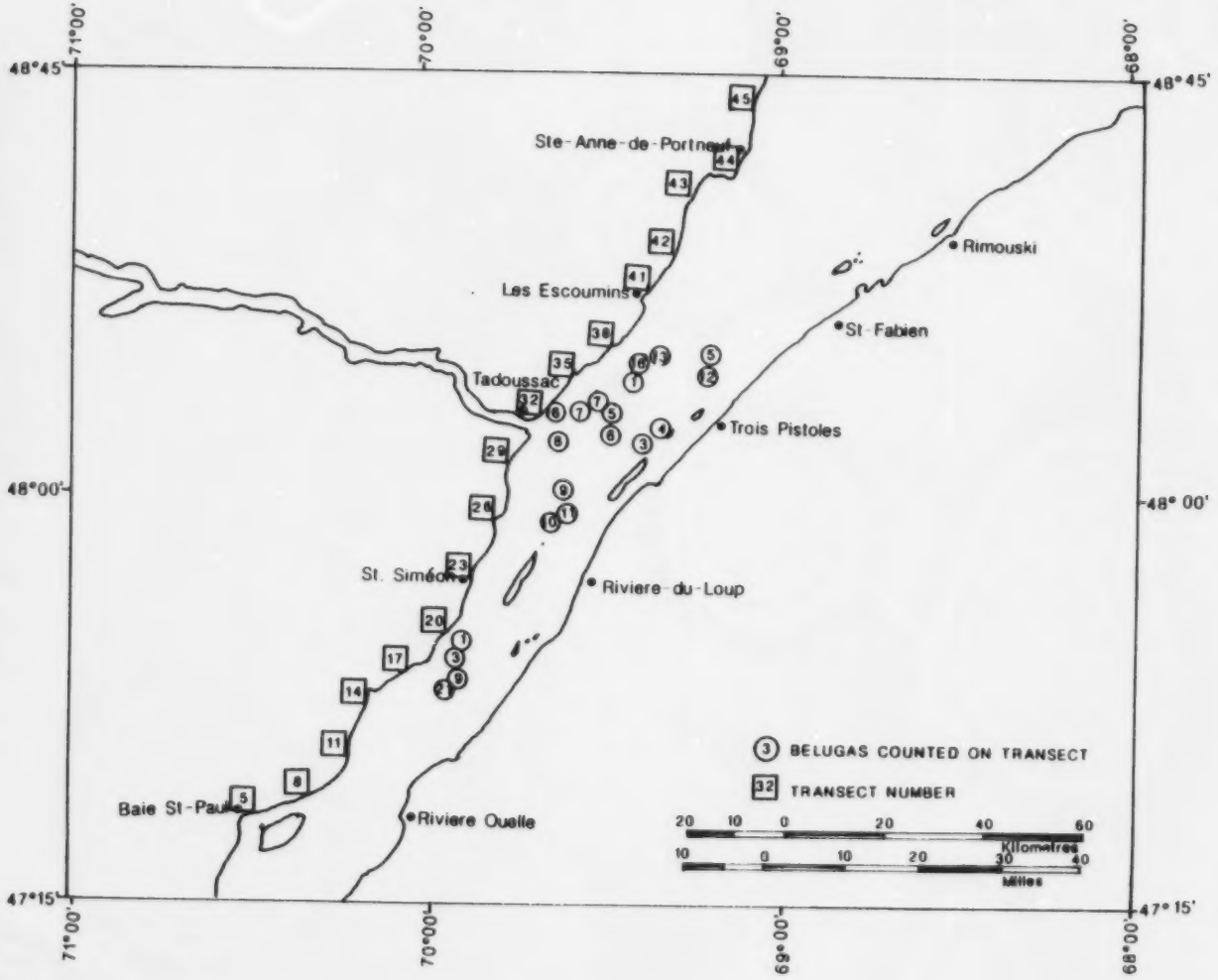

Figure 3. Observations of belugas on photographic aerial survey of the St Lawrence estuary, 31 August 1988.

Table 2. Population estimates and standard errors of St Lawrence belugas visible at the surface during aerial surveys in 1988 and 1990.

Year	Transect Group	Uncorrected for glare		Corrected for glare	
		Population estimate	Standard error	Population estimate	Standard error
1988	1	398.7	53.7	407.2	54.2
	2	20.0	26.5	20.0	26.5
	Total	418.7	59.9	427.3	60.3
1990	1	280.0	261.9	282.8	264.5
	2	34.7	25.4	35.3	25.9
	3	200.0	29.8	208.6	31.7
	2 & 3	234.7	39.2	243.9	40.9
	Total	514.7	264.8	526.7	267.6

apparent error coefficient of variation was 14.5% (Table 2). This is a good value to attain, given the inherent imprecision of sample surveys of small aggregated populations.

Glare correction factors after removing the overlap were generally low. On three transects (32, 33, and 36), the sun was abeam of the aircraft. As a result, the glare areas were at the side rather than the end of the frames, so they did not coincide with the overlap area at the end of the frames and were not much reduced by the overlap correction.

In 1990, the survey design and the flying conditions resulted in three groups of transects (Table 3). Transects 1 - 13, at the downstream end of the survey area, were spaced 6 n. mi apart and, owing to cloud cover, were flown at 3000 feet, with a resulting expansion factor of 8. From transect 13, where the main survey area was considered to start, the spacing changed to 2 n. mi. apart, but the flying continued to be at 3000 feet under cloud. The expansion factor resulting was 2.667 (8/3). From transect 22 and continuing to transect 50 at the upstream limit of the survey the spacing remained at 2 n. mi. apart, while clear skies permitted these transects to be flown at 4000 feet, with an expansion factor of 2. Because of the clear skies, the last group was the most seriously affected by sun glare; for the other two groups it was not a problem. Fewer counts (104 compared with 150 in 1988) were made in the closely spaced main survey area, but belugas were counted in numbers on one transect in the extension area where the transect spacing was 6 n. mi. (Table 3, Fig. 4). This had a large effect on the total population estimate. The overall estimate of the population arising

Table 3. Counts of beluga whales from photographic survey transects over the St Lawrence estuary, 12 September 1990.

Transect No	Count	Glare factor (%)	Corrected count	Transect No	Count	Glare factor (%)	Corrected count
Group 1: transects 1--13; S = 6 n. mi.; H = 3000 ft; k = 8							
12	35	1	35.35				
Group 2: transects 13--21; S = 2 n.mi.; H = 3000 ft; k = 8/3							
17	12	2	12.24	19	0	0	0.0
18	0	0	0.0	20	1	0	1.0
Group 3: transects 22--50; S = 2 n.mi.; H = 4000 ft; k = 2							
22	4	12	4.55	30	0	0	0.0
23	10	12	11.36	31	2	4	2.08
24	0	0	0.0	32	7	5	7.37
25	0	0	0.0				
26	9	2	9.18	38	4	0	4.0
27	19	5	20.0	39	9	0	9.0
28	4	7	4.30	40	13	0	13.0
29	6	7	6.45	41	13	0	13.0

from the survey was 514.7 not corrected for glare, and 526.7 corrected for glare. However, two frames on transect 12 in the extension area accounted for over 50% of that estimate (Table 2). The isolated large group, occurring on a single transect, also made a large contribution to the standard error of the estimate. The overall standard error was 267.6, mostly due to the isolated high count in the extension area.

An alternative estimate can be made for the total population by combining the survey estimate from the high coverage area with independent estimates of the size of the group of belugas that was seen off Les Escoumins at different times in September in the course of carrying out survey flights to study the distribution of the population. The combined total for transect groups 2 and 3 in 1990 was 234.7 uncorrected for glare and 243.9 corrected for glare. On a distribution survey flown on 11 September 1990, observers counted 75 belugas downstream of Ile aux Basques. The flight pattern was a wide zigzag not designed to cover the area exhaustively, and this is therefore a minimum value. Numbers downstream of Ile Verte can reach 120 - 150.

There is little good information on which to base a visibility correction for photographic aerial surveys of belugas. Shallowly submerged whales can be identified on aerial survey film - there are few other objects either on the surface or submerged that resemble the

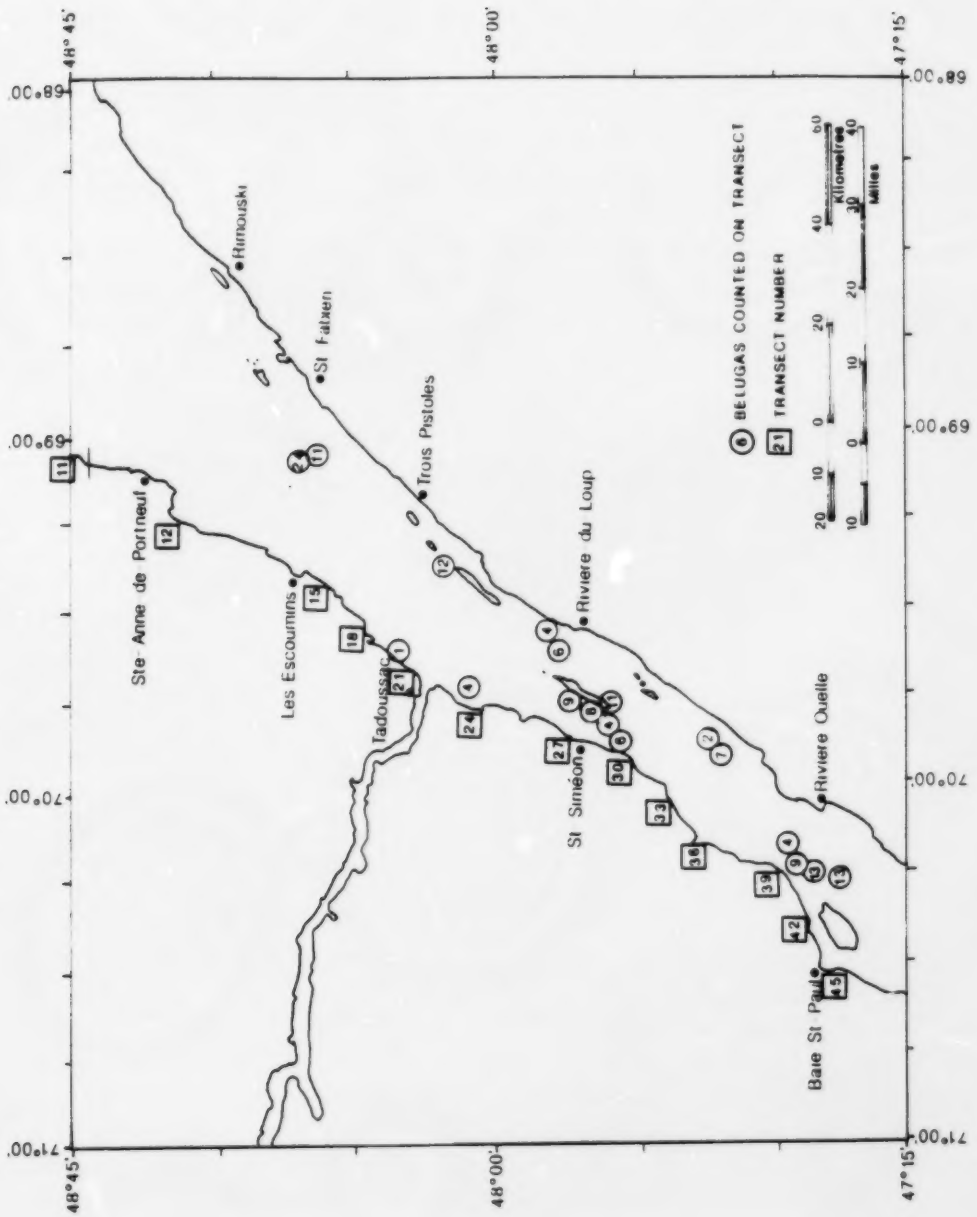

Figure 4. Observations of belugas on photographic aerial survey of the St Lawrence estuary, 12 September 1990.

blurred white comma-shaped image - but the probability of detection is small and decreases rapidly with depth. Furthermore, the proportion of such submerged images gives no estimate of how many might be out of sight. Surface studies of diving behaviour are of little value in estimating the proportion of the population that is visible to an airborne camera. Sergeant and Hoek (1988), by comparing whales seen in neighbouring frames, arrived at correction factors of 15% and 21% for different surveys. A study in north Baffin Island on the diving behaviour of narwhal estimated a correction factor of at least 100% (Dueck 1989), but it is not clear if this is applicable to all habitat areas and behaviour patterns, or only to areas with a high proportion of feeding activity. As a standard correction factor for the estimates obtained in these surveys, we have used the least of these values, viz. 15%. Application of a 15% correction factor to the 1988 estimate of 427 (std err. 60) yielded a corrected estimate of 491 (std err. 69.); the corresponding results for 1990 were 606 (std err. 308.) for the entire survey or 280 (std err. 47) for transect groups 2 and 3 only.

The Saguenay Fjord was not surveyed simultaneously with either photographic survey. Flights were made along the fjord on the day before and the day after the survey in 1988, but no belugas were seen on either day. On a distribution survey on 11 September 1990 (i.e. the day before the survey) over the entire length of the fjord, 23 belugas were counted at Baie Ste Marguerite; on 7 survey flights along the fjord in August, September and October 1990, including that of 11 September, a total of 101 belugas were counted, for a mean of 14.4. The maximum number counted was 59, the minimum was 0.

Table 4. Population estimates for beluga of the St Lawrence estuary, 1973 - 1990.

Year	Method	Corrected estimate	95% confidence interval or standard error	Source
1973	Photo (air)	443[a]	229--658	Sergeant & Hoek (1988)
1977	Visual (air)		300--350	Pippard (1985)
1982	Visual (air)	512[b]	360--715	Sergeant & Hoek (1988)
1984	Photo (air)	431[a]	187--773	"
1984	Visual (boat)	495[b]	±245	Lynas (1984)
1985	Visual (boat)	340		Béland et al. (1987)
1985	Photo (air)	530[a]	285--775	Sergeant & Hoek (1988)
1988	Photo (air)	491[a]	± 69	this report
1990	Photo (air)	607[a]	±308	this report

[a]corrected for visibility
[b]uncorrected for visibility

Other estimates of the size of the beluga population of the St Lawrence estuary with which these may be compared are shown in Table 4. Including all these estimates, and regressing the crude estimates of the population size against time, the estimated rate of change of the population is 9.1 (std err. 5.5) belugas/yr. Omitting the 1990 estimate, which we suspect of being biased upwards, gives a rate of change of 5.4 (s.e. 6.1) belugas/year. If the low estimates obtained by Pippard (1985) and Béland (1987) are omitted, the trends become 7.0 (s.e. 3.7) belugas/year including the 1990 estimate and 3.6 (s.e. 3.4) belugas/year without it. Even given the admitted imperfections of these population estimates, it seems difficult to sustain the hypothesis that the population is either increasing or decreasing by more than a few percent per year. A second conclusion is that the survey estimates may be more precise than the estimated sampling standard errors indicate. Although confidence limits as high as 770 or as low as 190 are calculated for several surveys, the numbers estimated usually fall in a much narrower band of 440 - 530.

PROPORTION AND DISTRIBUTION OF YOUNG BELUGAS

In the 1988 survey, there were few beluga calves definitely identified on the film. A total of 19 juveniles was arrived at, but half of these were rated as 'questionable', and there were

Table 5. Juvenile belugas counted from photographic aerial surveys of the St Lawrence in 1988 and 1990.

Year	Total count	Juveniles				
		At heel	Independent	Questionable	Total	as % of total count
1988	152	3	6	10	19	12.50
1990	148	23	4	0	27	18.24

only three that were counted as 'calves at heel' (Table 5.) The 1990 results were very different: there were no juveniles rated as 'questionable', and the total count of juveniles was higher. All juveniles were 18% of the population in 1990, and 'calves at heel' accounted for 88% of all juveniles. The larger number of 'calves at heel' obtained from the survey agrees with a high abundance in the proportion of grey juveniles recorded by observers in boats in the course of other studies in 1990. The St Lawrence population has been said to have a reproductive rate which at 8 - 9% per year is low compared with that estimated for Arctic populations at 14.5% (Sergeant 1986: Table V.) The 1988 survey, which had a low count of clearly identifiable calves, would support that judgement, but the 1990 results indicate that the reproductive rate is at least in some years capable of reaching the higher value.

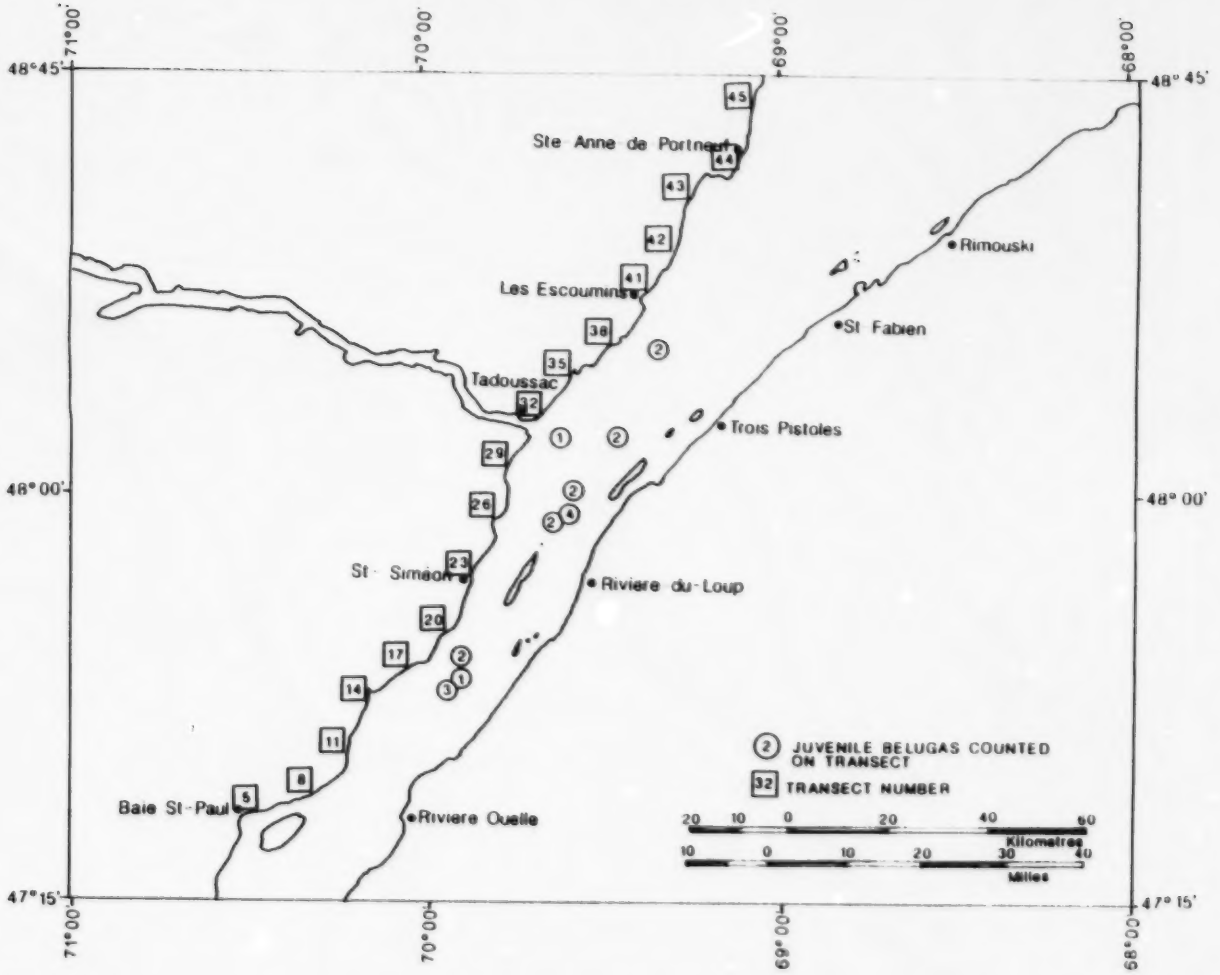

Figure 5. Distribution of juvenile belugas in the St Lawrence estuary determined from photographic aerial survey, 31 August 1988.

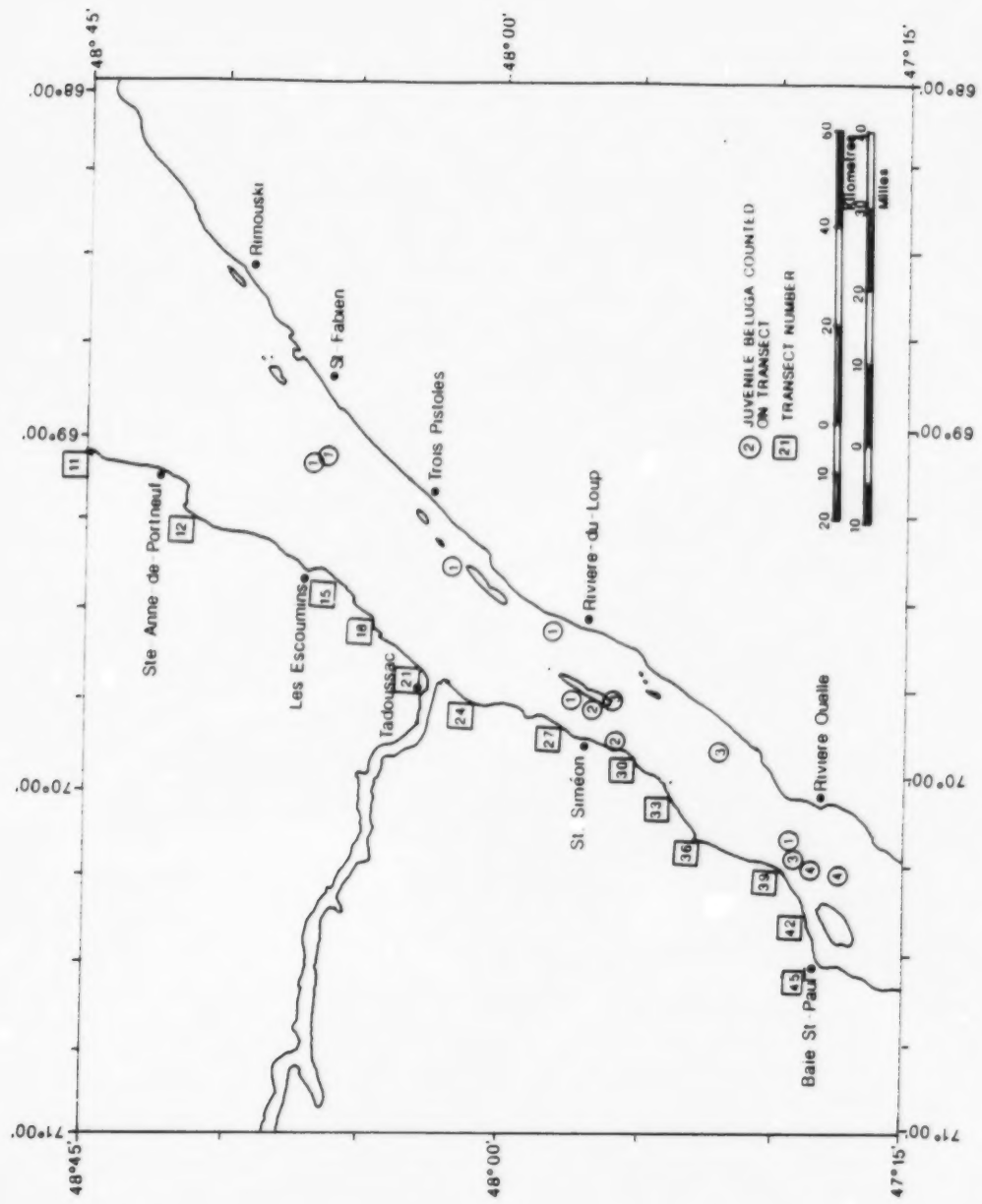

Figure 6. Distribution of juvenile belugas in the St Lawrence estuary determined from photographic aerial survey, 12 September 1990.

This difference between the two years in the proportion of calves at heel is probably not due to sampling error ($t > 2.7$, $p < 5\%$), nor to the small difference in the dates of the surveys in the two years. Equally, however, it does not necessarily represent a significant shift in reproductive performance. Belugas are known to have a long reproductive cycle, approximately 3 years between calves. Reproductive success in mammals is apt to vary considerably from year to year even in species with annual reproductive cycles, and this phenomenon has been well documented for some marine mammals (Smith and Hammill 1989). Reproductive response to year-to-year variations in ambient conditions in a species with a multi-year reproductive cycle would be expected to reveal itself as a tendency to synchrony of reproductive cycle, because years of poor ambient conditions that would inhibit the onset of ovulation in maturing young females would also inhibit successful conception among the older cohorts. This effect would be especially marked among the females of a population like the belugas of the St Lawrence, inhabiting a restricted range and all subjected to very similar conditions. It would result in a variation in natality rate, even between similar years, greater than would be predicted by a pure binomial distribution. To date, there have been no studies of the year-to-year variation in the natality rate of this or other populations of belugas, nor of whether the reproductive cycles of females show the predicted tendency to be synchronised.

Groups of females and calves have a distribution that favours the upstream end of the range of the population, i.e. the estuary above the entrance to the Saguenay (Sergeant 1986; Sergeant and Hoek 1988: Fig. 4), while belugas found downstream of the Saguenay are

Table 6. Distribution of juvenile belugas in the St Lawrence estuary determined from photographic aerial surveys in 1988 and 1990.

Year	Upstream of Saguenay			Downstream of Saguenay		
	Calves	Adults	%	Calves	Adults	%
1988	15	68	22.1	4	84	4.8
1990	24	100	24.0	3	48	6.1

usually all adults. This tendency is reflected in the distribution revealed in these surveys (Table 6; Fig. 5; Fig. 6). In both surveys, the proportion of juveniles upstream of the Saguenay was over 20%, while downstream it was 4 - 6%. It is seen that the larger number of juveniles in 1990, almost all upstream of the Saguenay, is associated with a larger count of accompanying adults in the upstream area, in such a way that the proportion of juveniles in that area remains more nearly constant. This supports Sergeant's (1986) suggestion of a segregation of lactating females with calves in the Ile aux Lièvres area.

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REFERENCES

Béland, P., R. Michaud and D. Martineau. 1987. Recensements de la population de bélugas (*Delphinapterus leucas*) du Saint-Laurent par embarcations en 1985. Rapp. tech. can. sci. halieut. aquat. 1545. 21 pp.

Breton, M. 1990. Un plan d'action pour la survie des bélugas du St-Laurent. Pp. 25 - 39 in J. Prescott and M. Gauquelin [ed.], Pour l'avenir du béluga. Compte rendu du Forum International pour l'avenir du béluga. Presses de l'Université du Québec.

Cochran, W. G. 1977. Sampling theory. Wiley, New York.

Dueck, L. 1989. The abundance of narwhal (*Monodon monoceros* L.) in Admiralty Inlet, N. W. T., Canada, and implications of behaviour for survey estimates. M. Sc. Thesis, U. of Manitoba, Winnipeg. Unpublished.

Kingsley, M. C. S. and G. E. J. Smith. 1981. Analysis of data arising from systematic transect surveys. Pp. 40 - 48 in F. L. Miller and A. Gunn, eds, Proc. Symp. Census and Inventory Methods for Populations and Habitats, Banff, April 1980. Contribution # 217, Forest, Wildlife and Range Experiment Station, U. of Idaho, Moscow, Idaho.

Lynas, E. M. 1984. Notes on the St Lawrence River white whale population. Oceantec (Ocean Research Information Society) Field Report 8401. 3 pp.

Pippard, L. 1985. Status of the St Lawrence river population of beluga, *Delphinapterus leucas*. Can. Field-Nat. 99: 438 - 450.

Reeves, R. R. and E. Mitchell. 1984. Catch history and initial population of white whales (*Delphinapterus leucas*) in the river and Gulf of St Lawrence, eastern Canada. Naturaliste can. (Rev. Écol. Syst.) 111: 63—121.

Reeves, R. and E. Mitchell. 1987. Hunting whales in the St Lawrence. Beaver 67: 35–40.

Sergeant, D. E. 1986. Present status of white whales *Delphinapterus leucas* in the St Lawrence estuary. Naturaliste can. (Rev. Écol. Syst.) 113: 61—81.

Sergeant, D. E. and W. Hoek. 1988. An update of the status of white whales, *Delphinapterus leucas* in the St Lawrence estuary, Canada. Biol. Conserv. 45: 287 - 302.

Smith, T. G. and M. O. Hammill. 1989. Variability in Arctic marine production shown by decrease in body condition and reduced reproductive output of ringed seal populations in the Amundsen Gulf and southeastern Beaufort Sea. Rapp. P.-v. Réun. cons. int. Explor. Mer 188: 252.